Tutorial Sheet-1

Interference

Q-1 If in an interference pattern, the ratio between maximum & minimum intensities is 36 : 1, find the ratio b/w the amplitude & intensities of the two interfering waves.

Given; $\frac{I_{max}}{I_{min}} = \frac{36}{1}$

find: $\frac{a_1}{a_2} = ?$ & $\frac{I_1}{I_2} = ?$

(i) we know; $\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2} = \frac{36}{1}$

$$\Rightarrow \frac{a_1+a_2}{a_1-a_2} = \frac{6}{1}$$

$$6a_1 - 6a_2 = a_1 + a_2$$

$$5a_1 = 7a_2$$

$$\boxed{\frac{a_1}{a_2} = \frac{7}{5}}$$ Ans//

(ii) As, $I \propto a^2$

So, $\frac{I_1}{I_2} = \left(\frac{a_1}{a_2}\right)^2 = \left(\frac{7}{5}\right)^2 = \frac{49}{25}$ Ans//

Q-2.) Two identical coherent waves produced interference pattern. Find the ratio of intensity at the centre of a bright fringe to the intensity at a point one quarter of the distance b/w two fringes from the centre.

find: 'I' at centre of bright fringe / 'I' at 1/4 dist. b/w 2 fringe from the centre = ?

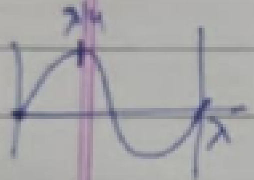
Sol

$$I = a_1^2 + a_2^2 + 2a_1a_2\cos\delta$$
$$= a^2 + a^2 + 2a^2\cos\delta \quad (\because a_1 = a_2 = a)$$
$$= 2a^2(1+\cos\delta) \quad \text{--- (1)}$$

At centre: $\delta = 0$ so, $\cos\delta = 1$

So, $I_{centre} = 2a^2(1+1) = 4a^2$ (maximum)

$$\Longrightarrow \frac{2\pi}{\Delta\phi} = \frac{\lambda}{\Delta x} \Rightarrow \Delta\phi = \frac{\Delta x}{\lambda}\cdot 2\pi$$



$$\Rightarrow \Delta\phi = \frac{\cancel{\lambda}}{\cancel{\lambda}}\cdot 2\pi \quad \{\Delta x = \lambda$$

$$\boxed{\Delta\phi = 2\pi}$$

at $\Delta x = \frac{\lambda}{4}$; $\Delta\phi = \frac{\cancel{\lambda}}{4\cancel{\lambda}}\cdot 2\pi \Rightarrow$

$$\boxed{\Delta\phi = \frac{\pi}{2}} \text{ at } 1/4 \text{ dist}$$

$$I_{1/4} = 2a^2\left(1 + \cos\frac{\pi}{2}\right) \quad \left\{\frac{\pi}{2} = 90^\circ\right\}$$

$$\boxed{I_{1/4} = 2a^2}$$

$$\text{Ratio} \Rightarrow \frac{I_{centre}}{I_{1/4}} = \frac{4a^2}{2a^2} = \frac{2}{1} \text{ Ans//.}$$

Q-3. In an interference pattern with two coherent sources, the amplitude of intensity variation is found to be 5% of the avg. intensity. Calc. the relative intensities of the interfering sources.
(1600 : 1)

Sol

Let $I_{avg} = 100$,

then, $$\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1+a_2)^2}$$

$$\frac{100+5}{100-5} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2}$$

$$\frac{a_1+a_2}{a_1-a_2} = \sqrt{\frac{105}{95}}$$

$$\frac{a_1}{a_2} = \frac{(\sqrt{105}+\sqrt{95})}{(\sqrt{105}-\sqrt{95})}$$

$$\frac{I_1}{I_2} \Rightarrow \frac{a_1^2}{a_2^2} = \frac{(\sqrt{105}+\sqrt{95})^2}{(\sqrt{105}-\sqrt{95})^2} = \frac{1600}{1}$$

4.) Two coherent sources of intensity ratio 9:1 interfere. Prove that in the interference pattern, $(I_{max} - I_{min})/(I_{max} + I_{min}) = 3/5$

Given; $\frac{I_1}{I_2} = \frac{9}{1}$

Proof: $\frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{3}{5}$

Sol

$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$

$I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$

So, LHS:

$$\frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{(\sqrt{I_1}+\sqrt{I_2})^2 - (\sqrt{I_1}-\sqrt{I_2})^2}{(\sqrt{I_1}+\sqrt{I_2})^2 + (\sqrt{I_1}-\sqrt{I_2})^2}$$

$$= \frac{2\sqrt{I_1 I_2}}{I_1 + I_2}$$

{given: $I_1 = 9I_2$}

$$= \frac{2\sqrt{9I_2 \cdot I_2}}{9I_2 + I_2}$$

$$= \frac{\cancel{2} \times 3 \cancel{I_2}}{5\,\cancel{10}\,\cancel{I_2}} = \frac{3}{5}$$ Hence proven!

5.) In a two slit interference pattern at a point we observe 10^{th} order maximum for $\lambda = 7000\,\text{Å}$. What order will be visible here, if the source of light is replaced by light of wavelength $5000\,\text{Å}$?

Given; $n_1 = 10$ $\quad n_2 = ?$
$\lambda_1 = 7000\,\mathring{A}$ $\quad \lambda = 5000\,\mathring{A}$

Sol we know, $y_n = \frac{n\lambda D}{d}$

So, $n_1\lambda_1 = n_2\lambda_2$

$$n_2 = \frac{10 \times 7000\,\mathring{A}}{5000\,\mathring{A}} = \frac{70}{5} = 14 \text{ Ans}$$

6) Two coherent sources are placed 0.18 mm apart and the fringes are observed on a screen 80 cm away. It is found that with a certain monochromatic source of light the fourth bright fringe is situated at a distance of 10.8 mm from the central fringe. Find the wavelength of light.

Given: $d = 0.18\,mm = 0.18 \times 10^{-3}\,m$
$D = 80\,cm = 80 \times 10^{-2}\,m$
$n = 4 \Rightarrow y_4 = 10.8\,mm = 10.8 \times 10^{-3}\,m$

Find: $\lambda = ?$

Sol
$$y_n = \frac{n\lambda D}{d} \Rightarrow y_4 = \frac{4 \times \lambda \times 80 \times 10^{-2}}{0.18 \times 10^{-3}} = 10.8 \times 10^{-3}$$

$$\lambda = \frac{10.8 \times 10^{-3} \times 0.18 \times 10^{-3}}{4 \times 80 \times 10^{-2}}$$

$$\lambda = \frac{108 \times 18 \times 25 \times 10^{-10}}{8}$$

$$\lambda = 6075\,\mathring{A} \text{ Ans}$$

Q-7.) Given light of wavelength 5100 Å from a narrow slit is incident on a double slit. If the overall separation of 10 fringes on a screen 200cm away is 2.0 cm, find the double slit separation.

Given: $\lambda = 5100 \text{Å} = 5100 \times 10^{-10} m$

$n = 10$

$y = 2 cm = 2 \times 10^{-2} m$

$D = 200 cm = 2 m$

find: $d = ?$

Sol

$$y = \frac{n \lambda D}{d}$$

$$\Rightarrow d = \frac{n\lambda D}{y} = \frac{10 \times 5100 \times 10^{-10} \times 2}{2 \times 10^{-2}}$$

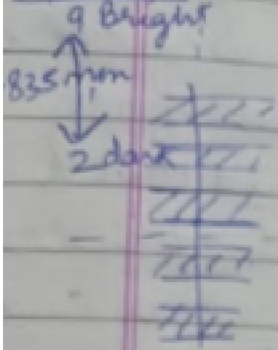
$$= \frac{5100 \times 1000}{10^7} \times 10^{-3} m$$

$$= 0.51 mm$$ Ans//

Ques 8.) In a YDSE, the slits are 0.5 mm apart and interference is observed on a screen placed at distance of 100cm from the slit. It is found that the 9th bright fringe is at a distance of 8.835 mm from second dark fringe from the center pattern. Find the wavelength of light used

Given: $d = 0.5\,mm = 0.5 \times 10^{-3}\,m$

$D = 100\,cm = 1\,m$



Distance of 9^{th} Bright & Dist. of 2^{nd} dark $= 8.835\,mm$

$= 8.835 \times 10^{-3}\,m$

find: $\lambda = ?$

Sol n^{th} Bright fringe:

$$y = \frac{n\lambda D}{d} = n\beta$$

$\Rightarrow$ For 9^{th} Bright: $y_9 = 9\beta$

Similarly, for Dark

$$y_n = \left(n - \frac{1}{2}\right)\beta$$

$\Rightarrow$ For 2^{nd} Dark $= \frac{3}{2}\beta$

$$\Rightarrow x_9 - x_2 = 9\beta - \frac{3}{2}\beta = 8.835 \times 10^{-3}$$

$$\Rightarrow \frac{15}{2}\beta = 8.835 \times 10^{-3}\,m$$

$$\beta = 1.178 \times 10^{-3}\,m = \frac{\lambda D}{d}$$

$$\lambda = \frac{1.178 \times 10^{-3} \times 0.5 \times 10^{-3}}{1}\,m$$

$$= 5.89 \times 10^{-7}\,m$$

$$= 5890\,\mathring{A}$$ Ans//

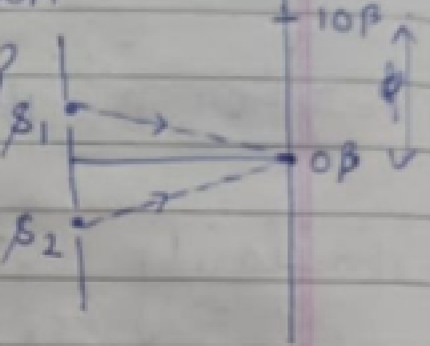
Q-9: In a particular two-slit Interference pattern with $\lambda = 6000 Å$, the zero order and the 10^{th} order maxima fall at micrometer readings 12.34 mm & 14.73 mm. If λ is changed to 5000 Å, deduce the positions of the zero and 20^{th} order fringes, the other arrangement remaining the same.

(12.34 mm, 16.34 mm, 8.36 mm)

Given: $\lambda_1 = 6000 Å \rightarrow \lambda_2 = 5000 Å$

$y_0 = 12.34\ mm$; $y_0' = ?$

$y_{10} = 14.73\ mm$; y_{20}



Sol: $y = \frac{n\lambda D}{d}$

$y_{10} = 10\beta$

$y_0 = 0\beta = 0$

So, $y_{10} - y_0 = 10\beta$

$14.73 - 12.34 = 10\beta$

$$\boxed{\beta_1 = 0.239\ mm}$$

Now, $\beta = \frac{\lambda D}{d} \Rightarrow \frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}$

$$\beta_2 = \beta_1 \frac{\lambda_2}{\lambda_1} = \frac{0.239\ mm \times 5000 Å}{6000 Å}$$

$$\boxed{\beta_2 = 0.199\ mm}$$

22:19

$y_{20} - y_0 = 20\beta_2$

[$y_0 = 12.34\,mm$ → Geometrically path diff. = 0]

$\rightarrow y'_{20} = 20 \times 0.199 + 12.34$
$= 3.98 + 12.34$
$= 16.32\,mm.$

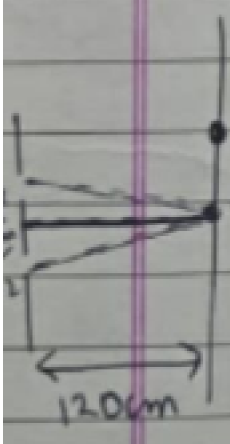
$\rightarrow y'_0 = y_0 = 12.34\,mm$] Ans//.

$\rightarrow y'_{20} = (12.34 - 3.98)\,mm$
$= 8.36\,mm.$

Q-10 A double slit of separation 1.5mm is illuminated by white light (b/w 4000Å to 8000Å). On a screen 120cm away coloured interference pattern is formed. If a pin hole is made on this screen at a distance of 3.0mm from the central white fringe, what wavelengths will be absent in the transmitted lights?

$y = 3mm = 0.3\,cm$
$D = 120\,cm$
$d = 1.5mm = 0.15\,cm$

(6818.2 Å, 5769.2 Å, 5000 Å, 4411.9 Å)



Those wavelength will be absent whose dark fringe fall on hole.

$$y_n = \left(n+\frac{1}{2}\right)\frac{\lambda D}{d} \quad [n = 0,1,2,3,4\ldots]$$

$$\frac{0.3 \times 0.15}{120}\,cm = \left(n+\frac{1}{2}\right)\lambda$$

$$\lambda = \frac{3\times10^8}{4000}\frac{1}{\left(n+\frac{1}{2}\right)}\,Å = \frac{75000}{\left(n+\frac{1}{2}\right)}\,Å$$

$n = 0,1,2,3,4\ldots$

$$\lambda = 75000 \times \left(1, \frac{1}{3}, \frac{1}{5}, \frac{1}{7}, \frac{1}{9}, \frac{1}{11}\right)\,Å$$

75000, 25000, 15000, 10714, 8333, $\boxed{6818}$, $\boxed{5769}$, $\boxed{5000}$, $\boxed{4411}$, 3948

Tutorial sheet - 2

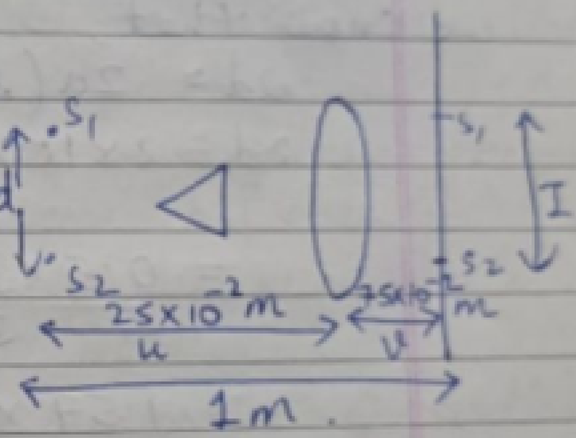
1.) In Fresnel's biprism experiment sod. light is used and bands of 0.02 cm in width are observed at a distance of 100 cm from the slit. A convex lens is then put b/w the observer & the prism to give an image of the source at a distance of 100 cm from the slit. The distance apart of the images is found to be 0.75 cm, the lens being 25 cm from the slit. Calculate the wavelength of sod. light.

Sol

$\beta = 2 \times 10^{-4}$ cm

$D = 1$ m.

$I = 75 \times 10^{-4}$ m.



we know that ;

$$\frac{I}{O} = \frac{v}{u}$$

$$\frac{75 \times 10^{-4}}{2d} = \frac{75 \times 10^{-2}}{25 \times 10^{-2}}$$

$$2d = 25 \times 10^{-4} \text{ m}$$

$$\beta = \frac{\lambda D}{2d} \Rightarrow \lambda = \frac{\beta \times 2d}{D} = \frac{2 \times 10^{-4} \times 25 \times 10^{-4}}{1}$$

$$= 50 \times 10^{-8}$$

$$\boxed{\lambda = 5000 \text{ Å}}$$

Q-2.) In Fresnel's biprism experiment the angle of glass prism is 3° & $\mu = 1.5$. Interference fringes are formed with source of wavelength 6000Å located 10cm from the biprism and source to screen distance is 100cm. Find the max. no. of fringes that can be observed.

$\alpha = 3^\circ = \frac{3 \times \pi}{180} = \frac{\pi}{60}$ radian

$\mu = 1.5$
$\lambda = 6000 \times 10^{-10} m$

$D = 1m$
$a = 10 \times 10^{-2} m$

we know that,

$$2d = 2a(\mu - 1)\alpha$$

$$2d = 2 \times 10 \times 10^{-2} (1.5 - 1) \frac{\pi}{60}$$

$$= \frac{0.5 \times 3.14 \times 10^{-2}}{3}$$

$$= \frac{1.57 \times 10^{-2}}{3}$$

$$= 0.523 \times 10^{-2}$$

$$= 52.3 \times 10^{-4} m$$

We know,

$$x = n \frac{\lambda D}{2d}$$

Since, x is the distance b/w image which is proportional to the distance b/w source point i.e., 2d.

22:19

$$2d = \frac{n\lambda D}{2d}$$

$$(2d)^2 = n\lambda D$$

$$n = \frac{(2d)^2}{\lambda D} = \frac{(52.3\times10^{-4})^2}{6000\times10^{-10}\times1}$$

$$= \frac{2735.29\times10^{-8}}{6\times10^{-7}}$$

$$= 455.8\times10^{7-8}$$

$$= 45.5$$

$$\boxed{n \simeq 45}$$

(3) A biprism of obtuse angle 176° is made of glass of R.I. 1.5. A slit illuminated with monochromatic light is placed 20cm behind & the width of interference fringes formed on a screen 80cm in front of biprism is found to be 8.25×10^{-3} cm. Calc. the wavelength of light.

$$\alpha = \frac{180-176}{2} = 2^\circ = \frac{2\times\pi}{180} = \frac{\pi}{90}\text{ radian}$$

$\mu = 1.5$.
$u = a = 20\times10^{-2}$ m
$v = b = 80\times10^{-2}$ m
$\beta = 8.25\times10^{-5}$ m

$\lambda = ?$

$D = a+b = v+u$
$= 1$ m.

we know,

$$\beta = \frac{\lambda D}{2d} \Rightarrow 8.25\times10^{-5} = \frac{\lambda\times1}{2d}$$

$$\lambda = 2d\times8.25\times10^{-5}$$

Q-2.) In Fresnel's biprism experiment the angle of glass prism is 3° & $\mu = 1.5$. Interference fringes are formed with source of wavelength 6000Å located 10cm from the biprism and source to screen distance is 100cm. Find the max. no. of fringes that can be observed.

$\alpha = 3^\circ = \frac{3 \times \pi}{180} = \frac{\pi}{60}$ radian

$\mu = 1.5$ $\quad\}\ D = 1m$

$\lambda = 6000 \times 10^{-10} m$ $\quad\}\ a = 10 \times 10^{-2} m$

we know that,

$$2d = 2a(\mu - 1)\alpha$$

$$2d = 2 \times 10 \times 10^{-2} (1.5 - 1) \frac{\pi}{60}$$

$$= \frac{0.5 \times 3.14 \times 10^{-2}}{3}$$

$$= \frac{1.57 \times 10^{-2}}{3}$$

$$= 0.523 \times 10^{-2}$$

$$= 52.3 \times 10^{-4} m.$$

We know,

$$x = n\frac{\lambda D}{2d}$$

Since, x is the distance b/w image which is proportional to the distance b/w source point i.e., $2d$.

$$2d = \frac{n\lambda D}{2d}$$

$$(2d)^2 = n\lambda D$$

$$n = \frac{(2d)^2}{\lambda D} = \frac{(52.3\times10^{-4})^2}{6000\times10^{-10}\times1}$$

$$= \frac{2735.29\times10^{-8}}{6\times10^{-7}}$$

$$= 455.8\times10^{7-8}$$

$$= 45.5$$

$$\boxed{n \simeq 45}$$

(3) A biprism of obtuse angle 176° is made of glass of R.I. 1.5. A slit illuminated with monochromatic light is placed 20cm behind & the width of interference fringes formed on a screen 80cm in front of biprism is found to be 8.25×10^{-3}cm. Calc the wavelength of light.

$$\alpha = \frac{180-176}{2} = 2^\circ = \frac{2\times\pi}{180} = \frac{\pi}{90} \text{ radian}$$

$\mu = 1.5$.
$u = a = 20\times10^{-2}\,m$
$v = b = 80\times10^{-2}\,m$
$\beta = 8.25\times10^{-5}\,m$

$\lambda = ?$

$D = a+b = v+u = 1m$.

we know,

$$\beta = \frac{\lambda D}{2d} \Rightarrow 8.25\times10^{-5} = \frac{\lambda\times1}{2d}.$$

$$\lambda = 2d\times8.25\times10^{-5}$$

we know that ;

$$2d = 2a(\mu - 1)\alpha$$

$$\lambda = 2 \times 20 \times 10^{-2} (1.5 - 1) \frac{3.14}{90} \times 8.25 \times 10^{-5}$$

$$= 5.757 \times 10^{-7} m$$

$$\boxed{\lambda = 5.757 \times 10^{-5} cm}$$

Q-(4) In a biprism experiment the eye-piece was placed at a distance of 120cm from the source. The distance b/w two virtual images was found to be 0.075cm Find the wavelength of light source, if eye-piece micrometer is moved through a distance 1.888cm for 20 fringes cross the field of view

Sol

$D = 1.2\,m$ $\quad 2d = 75 \times 10^{-5} m$

$\lambda = ?$

$$x = 1.888 \times 10^{-2} cm$$

$n = 20$

$$x = \frac{n\lambda D}{2d}$$

$$\lambda = \frac{x \times 2d}{nD} = \frac{1.888 \times 10^{-2} \times 75 \times 10^{-5}}{20 \times 1.2}$$

$$= \frac{141.6 \times 10^{-7}}{24}$$

$$= 5.9 \times 10^{-7} m$$

$$\boxed{\lambda = 5900\text{Å}}$$

22:19

Q-(5) A Fresnel biprism arrangement is set with Sod. light ($\lambda = 5893 Å$) and in the field of view of the eye piece we get 62 fringes. How many fringes shall we get if we replace the source by mercury lamp using (a) green filter ($\lambda = 5461 Å$) (b.) violet filter ($\lambda = 4358 Å$).

Sol

$\lambda_1 = 5893 Å \qquad n_1 = 62$

$\lambda_2 = 5461 Å \qquad n_2 = ?$

$\lambda_3 = 4358 Å \qquad n_3 = ?$

$$x = \frac{n\lambda D}{2d} = n_1\lambda_1 = \frac{x \times 2d}{D} \quad \text{—— (1)}$$

Similarly,

$$n_2\lambda_2 = \left(\frac{x \times 2d}{D}\right) \quad \text{—— (2)}$$

and

$$n_3\lambda_3 = \frac{x \times 2d}{D} \quad \text{—— (3)}$$

From (1), (2) & (3) we get

$$n_1\lambda_1 = n_2\lambda_2 = n_3\lambda_3$$

$$n_2 = \frac{n_1\lambda_1}{\lambda_2} = \frac{62 \times 5893}{5461} = 66.9$$

$$\boxed{n_2 \simeq 67}$$

$$n_3 = \frac{n_1\lambda_1}{\lambda_3} = \frac{62 \times 5893}{4358} = 83.8$$

$$\boxed{n_3 \simeq 83}$$

16:38

$m_3 \simeq 83$

Akash GLA

23 photos • November 22, 2021 22:19

Q-7. In Newton's rings exp., the air in the inter space is replaced by a liquid of R.I. 1.33, in what proportion would the diameters of the rings change?

we know that

$$D_n^2 = \frac{4n\lambda R}{\mu}$$

or $\mu \propto \frac{1}{D_n^2}$

$$D_n \propto \frac{1}{\sqrt{\mu}}$$

$$D_n \propto \frac{1}{\sqrt{1.33}} = \frac{1}{1.153} = 0.867 \text{ Ans}$$

Q-6 In Newton's rings exp. the diameter of 4^{th} & 12^{th} dark rings are 0.400 cm and 0.700 cm respectively. Deduce the diameter of 20^{th} dark ring.

$n = 4$

$n + p = 12 \Rightarrow p = 8$

$$\Rightarrow D_{n+p}^2 - D_n^2 = 4p\lambda R$$

$$D_{12}^2 - D_4^2 = 4 \times 8 \times \lambda R \quad \text{--- (1)}$$

$$D_{20}^2 - D_4^2 = 4 \times 16 \times \lambda R \quad \text{--- (2)}$$

$$\frac{D_{12}^2 - D_4^2}{D_{20}^2 - D_4^2} = \frac{8}{16}$$

$$2(D_{12}^2 - D_4^2) = D_{20}^2 - D_4^2$$

22:19

$D_{20}^2 = 2D^2$

Q-5. In Newton's rings exp., the air in the inter space is replaced by a liquid of R.I. 1.33, in what proportion would the diameters of the rings change?

we know that

$$D_n^2 = \frac{4n\lambda R}{\mu}$$

or $\mu \propto \frac{1}{D_n^2}$

$$D_n \propto \frac{1}{\sqrt{\mu}}$$

$$D_n \propto \frac{1}{\sqrt{1.33}} = \frac{1}{1.153} = 0.867 \text{ Ans}$$

Q-6 In Newton's rings exp. the diameter of 4^{th} & 12^{th} dark rings are 0.400 cm and 0.700 cm respectively. Deduce the diameter of 20^{th} dark ring.

$n = 4$

$n + p = 12 \Rightarrow p = 8$

$$\Rightarrow D_{n+p}^2 - D_n^2 = 4p\lambda R$$

$$D_{12}^2 - D_4^2 = 4 \times 8 \times \lambda R \quad \text{--- (1)}$$

$$D_{20}^2 - D_4^2 = 4 \times 16 \times \lambda R \quad \text{--- (2)}$$

$$\frac{D_{12}^2 - D_4^2}{D_{20}^2 - D_4^2} = \frac{8}{16}$$

$$2(D_{12}^2 - D_4^2) = D_{20}^2 - D_4^2$$

22:19

$D_{20}^2 = 2D_{12}^2 - D_4^2$

$= 2(0.7)^2 - (0.4)^2$

$D_{20}^2 = 0.98 - 0.16$

$= 0.82$

$D_{20} = \sqrt{0.82} = 0.906$ cm Ans //

-8 Light containing two wavelengths λ_1 & λ_2 falls normally on a Plano Convex lens of radius of curvature R resting on a plane glass plate. If n^{th} dark ring due to λ_1 coincides with $(n+1)^{th}$ dark ring due to λ_2. then prove that the radius of n^{th} dark ring of wavelength λ_1 is $\sqrt{\frac{\lambda_1 \lambda_2 R}{(\lambda_1 - \lambda_2)}}$.

Sol the diameter of n^{th} dark ring $= D_n^2 = 4n\lambda_1 R$ — ①

" " " $(n+1)^{th}$ " $= D_{n+1}^2 = 4(n+1)\lambda_2 R$ — ②

ATQ : $D_n^2 = D_{n+1}^2$

then, $\cancel{4}n\lambda_1 R = \cancel{4}(n+1)\lambda_2 R$

$n\lambda_1 = (n+1)\lambda_2$

Or $n = \frac{\lambda_2}{\lambda_1 - \lambda_2}$ — ③

Now from ② & ③ : we get,

$D_n^2 = 4n\lambda_1 R = \frac{4\lambda_1\lambda_2 R}{\lambda_1 - \lambda_2}$

& $\left(\frac{D_n}{2}\right)^2 = \frac{\lambda_1\lambda_2 R}{\lambda_1 - \lambda_2}$

$r_n^2 = \frac{\lambda_1\lambda_2 R}{\lambda_1 - \lambda_2} \Rightarrow \boxed{r_n = \sqrt{\frac{\lambda_1\lambda_2 R}{\lambda_1 - \lambda_2}}}$

Tutorial Sheet - 3
Diffraction & Polarisation

Q-(1.) A parallel beam of Sod. light is normally incident on a plane diffraction grating having 4250 lines per cm and a second order spectral line is observed at angle of 30°. Find the wavelength of light.

Given; $\frac{1}{(e+d)}$ = No. of lines per cm = 4250

$n = 2$; $\theta = 30°$

find : $\lambda = ?$

we know,

$$(e+d)\sin\theta = n\lambda$$

$$\lambda = \frac{(e+d)\sin\theta}{n}$$

$$= \frac{\sin 30°}{4250 \times 2} \text{ cm}$$

$$= \frac{1 \times 10^8}{2 \times 2 \times 4250} \text{ Å}$$

$$= \frac{100 \times 10^3}{17}$$

$$= 5882 \text{ Å}$$ Ans

Q-② In a grafting spectrum, which spectral line in 4^{th} order will overlap with 3^{rd} order line of $5461\,\mathring{A}$?

→ In Diffracting grating:

$$(e+d)\sin\theta = n\lambda$$

→ if n^{th} order of λ_1 coincides with $(n+1)^{th}$ order of λ_2

$$(e+d)\sin\theta = n\lambda_1 = (n+1)\lambda_2$$

$$\lambda_2 = \frac{n\lambda_1}{(n+1)}$$

Given:
$\left\{ \begin{array}{l} n = 3 \\ \lambda_1 = 5461\,\mathring{A} \\ (n+1) = 4 \end{array} \right\}$

$$\lambda_2 = \frac{3 \times 5461}{4}$$

$$= 4095.75$$

$$\boxed{\lambda_2 \simeq 4096\,\mathring{A}}$$

Q-③ What is the highest order spectrum which may be seen with light of wavelength 6×10^{-5} cm by mean of a grating with 5000 lines/cm?

Given $\lambda = 6 \times 10^{-5}$ cm ; $n = ?$; $\frac{1}{(e+d)} = 5000$

we know, $(e+d)\sin\theta = n\lambda$

for highest order : $\sin\theta = \text{max.} = 1 = \sin 9$

So,
$$n = \frac{(e+d)\sin\theta}{\lambda}$$

$$= \frac{1 \times 10^5}{5000 \times 6}$$

$$= \frac{100}{3} = 3.333$$

$\boxed{n \simeq 3}$ Ans.

Ques(4): A 20 cm long tube containing 48 cm^3 of sugar Soln rotates the plane of polarisation by 11°. If the Specific rotation of Sugar is 66°, Calculate the mass of sugar in solution.

Given: $l = 20cm$ } $\theta = 11^\circ$

$c = \frac{x\, gm}{48\, cm^3}$ } $S = 66^\circ$

Find: $x = ?$

we Know, $S = \frac{10\,\theta}{l \times c}$

from given values:

$$\cancel{66}\;6 = \frac{\cancel{10} \times \cancel{11} \times \cancel{48}\;24}{\cancel{20} \times x}$$

$$x = \frac{42}{6} = 4 \Rightarrow \boxed{x = 4}$$

Ans. So, mass of sugar in Soln, $x = 4$ gm

-(5) The plane of polarisation of plane polarised light is rotated through 6.5° in passing through a length of 2.0 dm of sugar solution of 5% concentration. Calculate the specific rotation of sugar solution.

Given: $\theta = 6.5^\circ$ } $c = 5\% = 5 \times 10^{-2}$ gm/cc

$l = 2.0\, dm$ }

Find: $S = ?$

22:19

we know, $S = \frac{\theta}{l \times C}$

$= \frac{6.5 \times \cancel{100}^{\cancel{50}\, 10}}{\cancel{2} \times \cancel{5}}$

$= 6.5 \times 10$

$= 6.5$

$\boxed{S = 6.5^\circ}$ Ans

Q-6: Impure sugar of 80gm is dissolved in a litre of water. The solution gives an optical rotation of 9.9° when placed in a tube of length 20cm. If the specific rotation of pure sugar solution is 66 deg $(dm)^{-1}$ $(gm/cc)^{-1}$, find % purity of sugar sample.

Given: Sugar sample dissolved in a 1L water = 80g

$\theta = 9.9^\circ$; $l = 20cm = 2\,dm$; $S = 66°(dm)^{-1}(gm/cc)^{-1}$

Find: % purity ~~of sample~~ = ?

Sol: we know, $S = \frac{\theta}{l \times C}$

$C = \frac{9.9}{2 \times 66} = 0.075\ g/cc$

$(\because 1L = 10^3 cc)$

Pure sugar $\Rightarrow \boxed{C = 75\ g/L}$

$\%\text{purity} = \frac{\text{Pure Sugar}}{\text{Total Sugar Sample}} \times 100 = \frac{75 \times 100}{80}$

$\boxed{\%\text{purity} = 93.75\%}$ Ans

Scanned by CamScanner

Q-(7) A Sugar solution in a tube of length 20cm produces optical rotation of 13°54′. The soln is then diluted to one - third of its previous conc. Find the optical rotation produced by 30cm Long tube containing the dilute soln.

Given

Before diluting	After diluting to 1/3rd
$l = 20cm = 2dm$	$l = l' = 30cm = 3dm$
$\theta = 13°54' = 13.9°$	$\theta = \theta'$
conc $= C$	conc $= C' = \frac{C}{3}$

we Know, $S = \frac{\theta}{l \times C}$ (Before dilution)

and $S = \frac{\theta'}{l' \times C'}$ (After dilution)

So, $\frac{\theta}{l \times C} = \frac{\theta'}{l' \times C'}$

$$\frac{13.9°}{2 \times \cancel{C}} = \frac{\theta' \times \cancel{3}}{\cancel{3} \times \cancel{C}}$$

$$\theta' = \frac{13.9°}{2}$$

$$\boxed{\theta' = 6.95°}$$ Ans.

22:19